Using image analysis to characterize fibril porous media

Problem Description

Characterizing microstructure of porous media play very important role in variety of industrial applications as well as mathematical modeling of those applications. For example, in filtration business, the performance of the filter, i.e., the permeability and the retention, are largely impacted by microstructure properties such as, the pore size distribution and pore connectivity. Experiments such as mercury intrusion porosimetry, which can estimate the pore size distribution has been used in the industry. On the other hand, researchers are also trying to create virtual structures to mimic the fibril porous media, using statistics of other microstructure properties like fiber size distribution and fiber orientation distribution. Then the pore size distribution can be obtained for those virtual structures and compared with other experiment techniques like mercury intrusion porosimetry.

Scanning Electron Microscope (SEM) has been a very common and useful tool to provide images of surface microstructures. The images produced are usually in grey scale and the resolution of a SEM is about 10 nanometers (nm). The disadvantage of SEM is that SEM focuses on the sample’s surface and its composition other than the details about internal composition. However, if assuming the porous media is homogeneous along the depth direction, we can use the information learned from SEM images of the surface of the material. For porous media having fibril structure, the SEM image can look like a pan of spaghetti, which means that fibers are curved, the density of fibers per area is large and there are lots of cross over between fibers. Hence the image analysis of those images can be very challenge. The goal of the workshop is to establish a robust mathematical model to analyze SEM images to obtain fiber properties.

Here are some questions we have:

1. There are some algorithms from software such as ImageJ, how do they work? What are the advantages and disadvantages for porous media with fibril structures?
2. How to combine fiber size distributions from images of different magnification/resolution? In some materials, the spread of fiber size distribution can be very large, and it is not possible to get one SEM image with largest fiber and smallest fiber both resolved very well. Hence the SEM images we usually get have different resolution for different sample size.